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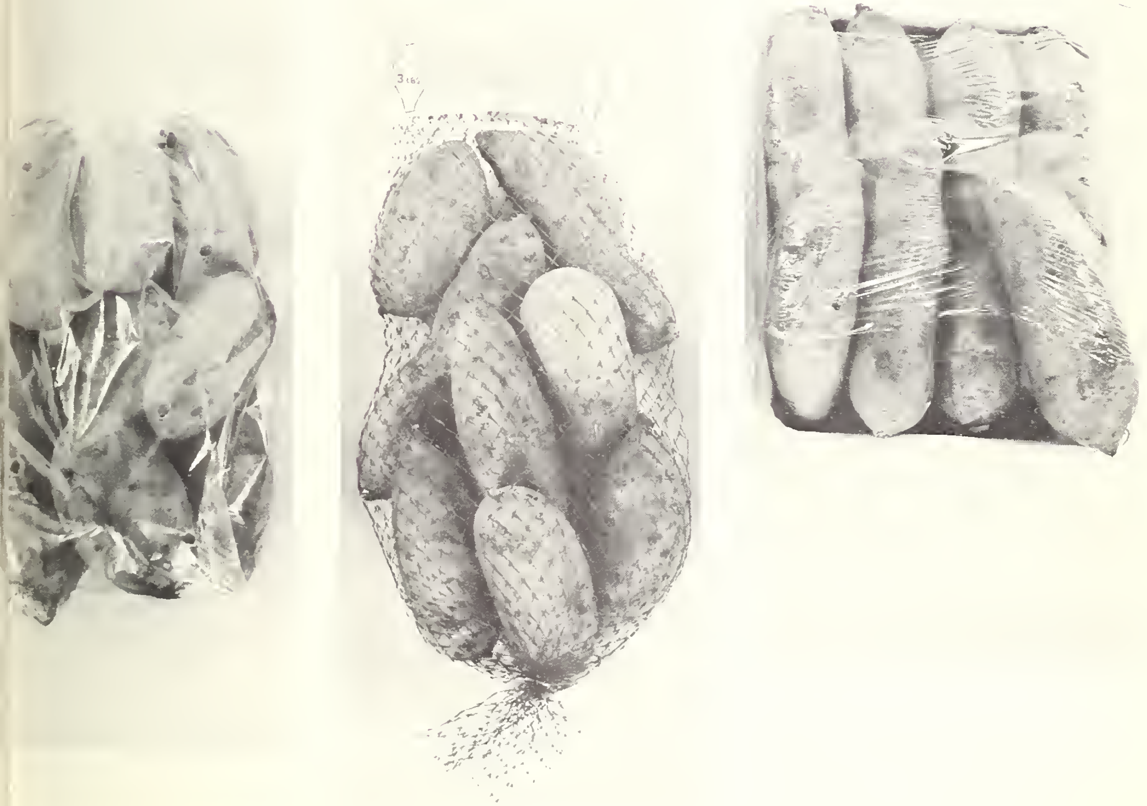
# CONSUMER PACKAGING AND DECAY CONTROL OF *Sweetpotatoes*



MARKETING RESEARCH REPORT NO. 650 • UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL MARKETING SERVICE • MARKET QUALITY RESEARCH DIVISION

# Preface

This study is part of a broad program of marketing research designed to maintain quality of farm products, improve marketing services, and hold down costs by increasing the efficiency of marketing farm produce.

The cooperation of the following organizations and firms is gratefully acknowledged:

Bardin Bros., Inc., Wilson, N. C.; Godwin Produce Co., Dunn, N. C., Corbett Package Co., Wilmington, N. C., and Atlantic County Market Growers, Inc., Egg Harbor, N. J., for providing some of the sweetpotatoes.

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# Contents

| | Page |
|---|---|
| Summary | 3 |
| Background | 3 |
| Methods | 4 |
| Results and discussion | 7 |
| Package ventilation | 7 |
| Decay and weight loss of packaged sweetpotatoes | 8 |
| Method of rinsing after treatment | 10 |
| Root trimming and holding temperature | 11 |
| Delaying chemical treatment | 11 |
| Chilling before chemical treatment | 13 |
| Literature cited | 13 |

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# Consumer Packaging and Decay Control of Sweetpotatoes

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## Summary

Packaging sweetpotatoes in consumer-size units has been tried many times since the introduction of plastic films. Heretofore, the development of soft rot in the packaged roots usually prevented successful commercial packaging. Since sodium o-phenylphenate tetrahydrate (SOPP) was found to inhibit decay of sweetpotatoes and a residue tolerance was established by the U. S. Food and Drug Administration, commercial interest in consumer packaging has increased and the SOPP treatment has been tested in conjunction with various types of consumer packages.

In numerous laboratory holding tests, Rhizopus soft rot of washed, graded, and packaged roots of several sweetpotato varieties usually was reduced more than 50 percent by SOPP treatment. Other rots were not significantly reduced.

Weight loss from sweetpotatoes in polyethylene mesh bags and in bulk was about three times as great as from sweetpotatoes packaged in perforated polyethylene bags. Weight loss from tray-packed roots varied with type of wrap and film used. The tray pack permitted some control of ventilation.

A delay in treating sweetpotatoes with SOPP after they were injured in handling reduced the effectiveness of the treatment. The effectiveness of the treatment depended upon the temperature at which roots were held after injury and the elapsed time before treatment.

The SOPP treatment reduced soft rot even in chilled sweetpotatoes, but control of soft rot in severely chilled roots was not satisfactory.

## Background

The development of the sodium o-phenylphenate tetrahydrate (SOPP) treatment to control soft rot of sweetpotatoes during marketing (*29*)[1] renewed interest in consumer packaging of this crop. With the establishment of the treatment in several packinghouses in North Carolina and Georgia the need for more information related to the treatment became apparent.

Consumers have shown a preference for sweetpotatoes that are attractively packaged, clean, and free of disease, injury, and defects (*3, 6, 7, 9, 22, 23, 42, 47, 50*). The amount purchased from bulk displays has averaged between 2 and 4 pounds (*3, 4, 7, 8, 23*). A 3-

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[1] Italic numbers in parentheses refer to items in Literature Cited, p. 13.

pound consumer-size package has usually been preferred over larger packages, although a 4- or 5-pound package has not been too large for many consumers (*8, 10, 23, 36, 50*). Consumers prefer medium-size roots about 2¼ to 2¾ inches in diameter weighing about 4 to 10 ounces (*3, 8, 9, 34, 42, 47*). However, roots from 1¾ to 3¼ inches in diameter have sold well, and some equipment to size sweetpotatoes has been tested (*35*). Uniformity of size, as well as other factors contributing to uniformity and quality, has influenced consumer acceptance (*3, 5, 9, 42, 47*). Often, price has been of less importance than quality (*3, 42*).

Decay caused by the soft rot organism (*Rhizopus nigricans.* Ehrb.) is the principal cause of spoilage of sweetpotatoes during marketing and while they are in the hands of the consumer (*4,24,43,49*). Black rot (*Endoconidophora fimbriata* (Ell. and Halst.) Davidson) is the second most serious market disease of sweetpotatoes (*43,49*). Spoilage resulting from these two diseases, especially soft rot, has been the primary reason why marketing of sweetpotatoes in consumer packages has expanded so slowly in retail stores. The brief period in transit is often too short for diseases to develop noticeably (*33,37,40*), but temperatures in transit are often favorable for infection. Decay usually develops while the sweetpotatoes are in the hands of the wholesaler, retailer, or consumer (*4,22,23,24*).

To fit into modern self-service operations in supermarkets, sweetpotatoes need to be packaged in consumer-size units. Several advantages of consumer packaging and efforts to capitalize on these advantages have been reported (*1,2,3,4,36*) as well as the problems (*19,42*). An increase in total sales of sweetpotatoes has often resulted from retail displays of both bulk and packaged sweetpotatoes (*14,36*). Consumers accepted tray packs, polymesh bags, and polyethylene bags of sweetpotatoes readily in studies conducted in Virginia and North Carolina (*4,14*). Observations that film-wrapped trays offered some protection to the roots and made an attractive display was similar to the response with film-wrapped trays of peaches (*25,48,50*).

Methods of controlling soft rot and black rot have been sought for many years, and various control measures consisting of re-curing (*39*), curing at elevated temperatures (*28*), heat treatments (*11, 30*), and chemical treatments (*5, 17, 18, 27*) have been reported. A practical method involving the use of borax was developed (*40,*' *41*) and recommended (*15*). Later the use of borax on roots intended for food was disapproved by the U.S. Food and Drug Administration, and the recommendation was withdrawn (*16*). Recommendations for controlling soft rot and black rot during marketing have consisted of avoiding mechanical injury, curing before storage, and disinfection of grading equipment (*16, 20, 21, 38*). Recently control of soft rot with a postharvest SOPP treatment was discovered, and use of SOPP on sweetpotatoes going into marketing channels has since been approved by the Food and Drug Administration with a residue tolerance of 15 p.p.m. expressed as o-phenylphenol (*29, 32*).

The tests reported here were undertaken to extend the information on handling practices, to evaluate various types of packages for quality maintenance, and to evaluate the SOPP treatment as an aid in successful consumer packaging of sweetpotatoes. Research was conducted with sweetpotatoes grown in North Carolina, Maryland, and New Jersey.

The use of a chemical treatment should serve as a supplement to good handling and marketing practices and other methods of maintaining the quality of sweetpotatoes. To determine how to further reduce losses tests were conducted involving handling methods related to the effective use of the SOPP treatment.

# Methods

Sweetpotatoes used were washed and usually graded commercially before any treatments were applied. Roots were immersed in SOPP solution (0.5 or 1.0 percent) until thoroughly wet, about 30 seconds unless otherwise specified. The treated roots were rinsed with water with a single row of nozzles across the conveyor or briefly immersed in fresh water. After treating, all roots were allowed to drain briefly before packaging, except a few which were rinsed by immersion after packaging in polyethylene mesh bags.

Soft rot and other rots are reported as a percentage of the roots developing decay.

Molded pulp trays measuring approximately 8½ by 9 inches and 1 to 1¾ inches deep were filled with 3 pounds of roots and either completely overwrapped or sleeve wrapped with shrinkable film (polystyrene or polyvinyl chloride). These tests were made with various widths and gages of the shrink film. Keeping quality of roots in these overwrapped trays was compared with roots packaged in plastic mesh or perforated polyethylene bags (fig. 1). Perforated 1.5-mil polyethylene bags were included because this type of bag is relatively inexpensive and has proved satisfactory for numerous kinds of heavy produce. Different numbers of perforations in polyethylene bags were tested because ventilation has been necessary for other produce in bags to obtain a satisfactory shelf life and prevent injury from accumulated carbon dioxide (*26, 31, 44, 46*).

Master containers of corrugated fiberboard were used for holding most of the consumer packages (figs. 2 and 3), although some 3-ply kraft paper baler bags were used in some of the holding tests. Standard tub bottom bushel and half-bushel baskets of sweetpotatoes were also included for comparisons as containers commonly used for bulk handling.

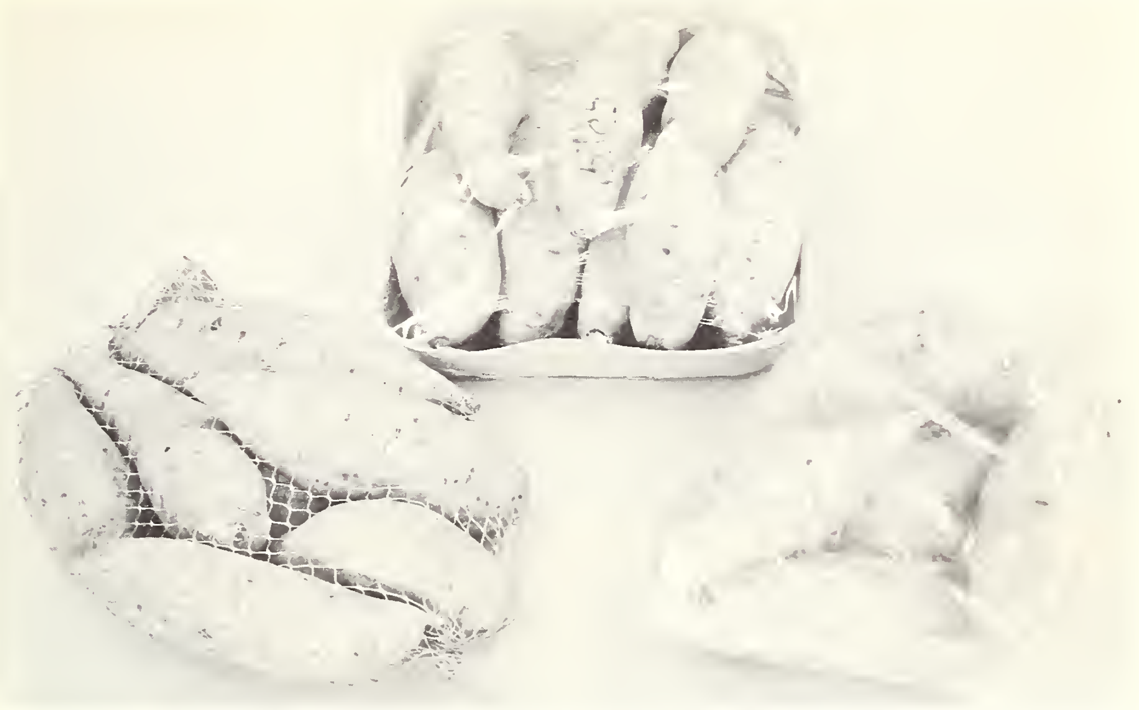
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Figure 1.—Sweetpotato consumer packages: Three-pound polymesh bag (left), perforated polyethylene bag (right), and tray pack overwrapped with shrinkable film (center).

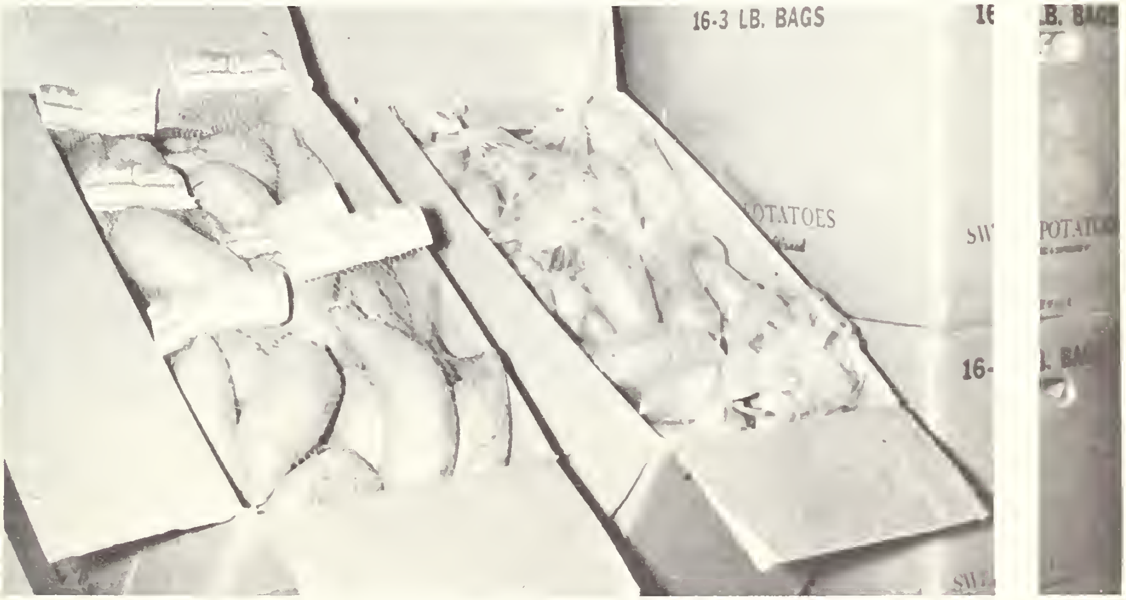

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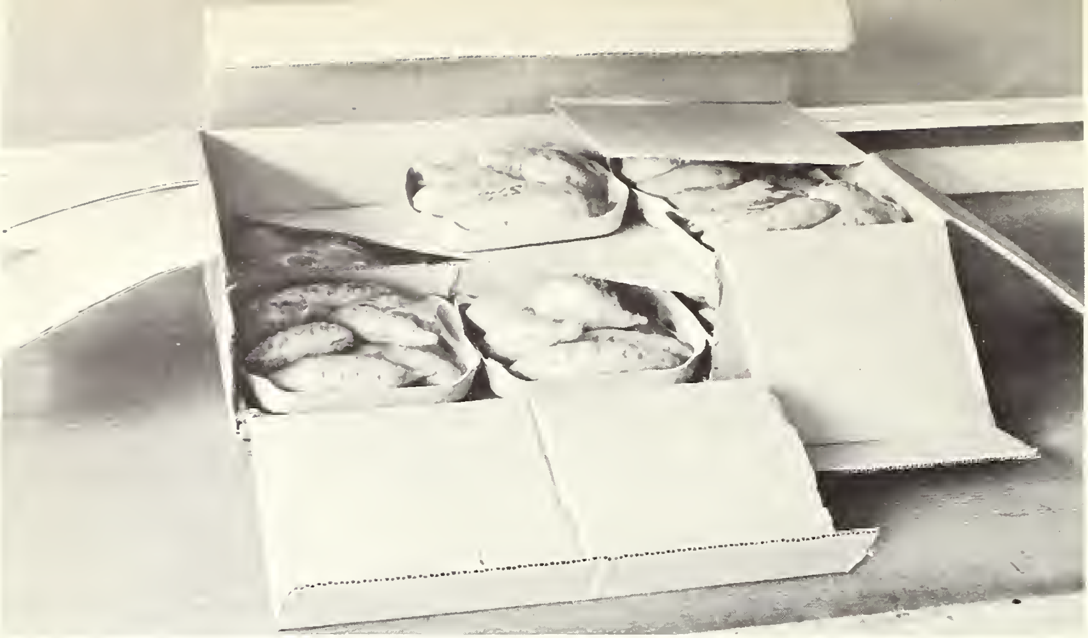
Figure 2.—Master containers for the polymesh and polyethylene bags held sixteen 3-pound bags and were approximately 20 by 11 by 12¾ inches. Another master container used held twelve 3-pound bags and measured approximately 16⅞ by 12⅝ by 10⅜ inches.



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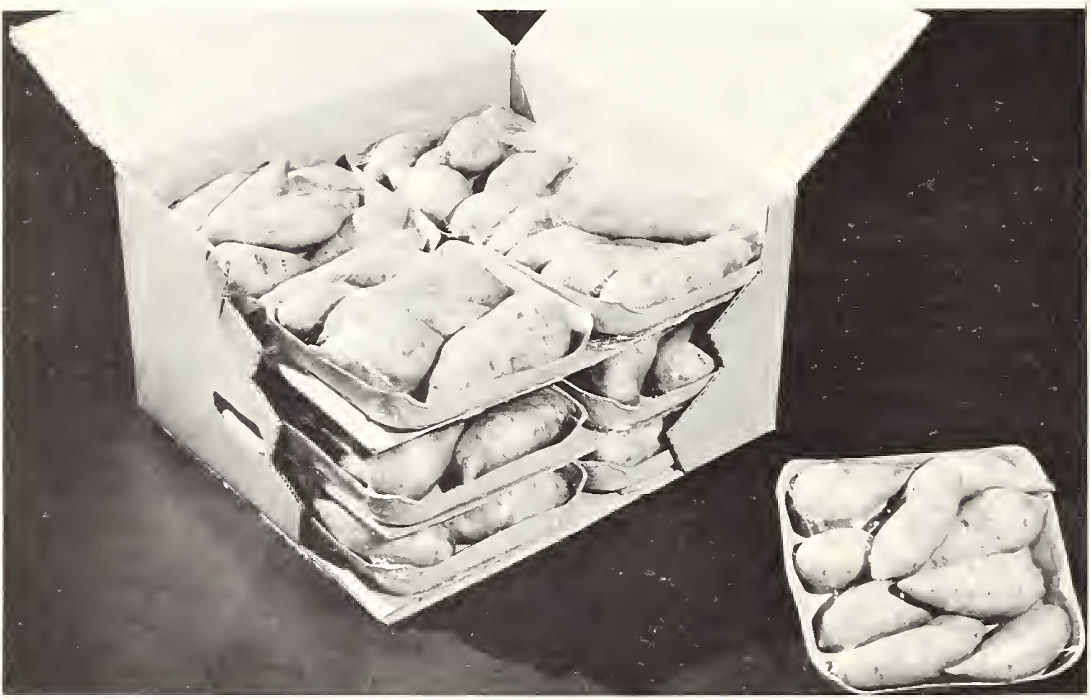

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FIGURE 3.—Master containers for 3-pound tray packages. Upper container holds 2 layers of 6 trays each and has a horizontal divider with vertical support to protect the packages (28½ by 17½ by 7 inches). Lower container holds 3 layers of 4 trays each with 2 horizontal dividers, which rest on the packages (19 by 16½ by 10 inches).

# Results and Discussion

## Package Ventilation

Polyethylene is a highly moisture-retentive film. In preliminary tests, polyethylene bags were perforated with different numbers of ¼-inch ventilation holes, then filled with sweetpotatoes and the relative humidity within the bags was determined at intervals for several days. As expected, nonperforated bags and bags perforated with only four holes maintained a very high humidity around the roots, averaging 98 percent or higher (table 1). While high humidity (85 to 90 percent) is desirable, humidity approaching saturation is undesirable during marketing as rooting, mustiness, and condensation in the bags may be severe and thus reduce salability.

Perforating 3- to 5-pound polyethylene bags with 16, 24, or 48 holes resulted in a lower and more desirable relative humidity within packages. Fogging, rooting, sprouting, and excess dampness were either eliminated or reduced by using bags with 24 or 48 perforations. Weight losses from sweetpotatoes increased with each increase in the number of perforations, as shown in table 1, but improvement in keeping quality with at least 24 holes offset this disadvantage. Only four holes were sufficient to prevent any harmful accumulation of carbon dioxide or depletion of oxygen, but more perforations were required to avoid excessively high humidities and to reduce fogging of the film.

All subsequent tests with sweetpotatoes in polyethylene were with bags ventilated with 24, 28, or 32 ¼-inch perforations.

Tray packs overwrapped with shrinkable film, in addition to partly immobilizing the roots and thus protecting them from injury, can be modified by the film selected and the degree of ventilation. The following shows the weight loss of cured Centennial sweetpotatoes packaged in 3-pound molded-pulp trays (measuring 8½ by 9 inches with 1- to 1¾-inch sides) with different types of heat shrinkable film wraps when held 7 days at 70° to 80° F. and 35 to 60 percent relative humidity:

| Type of film, initial width, and type of wrap | Weight loss |
|---|---|
| | *Percent* |
| Polystyrene, 100-gage, biaxially oriented: | |
| 10″ width, sleeve wrap | 6.2 |
| 11″ width, sleeve wrap | 5.8 |
| 12″ width, sleeve wrap | 4.4 |
| Polyvinyl chloride, 75-gage, machine oriented: | |
| 9″ width, sleeve wrap | 6.1 |
| 10″ width, sleeve wrap | 4.4 |
| 11″ width, sleeve wrap | 2.4 |
| Polyvinyl chloride, 75-gage, biaxially oriented: | |
| 11″ width, sleeve wrap | 5.9 |
| 12″ width, sleeve wrap | 4.6 |
| Polyvinyl chloride, 75-gage, machine oriented: | |
| 12″ width, overwrap nonperforated | 1.4 |
| 12″ width, overwrap with needle perforations | 2.4 |
| Control (no film wrap) | 7.6 |
| Least significant difference at 5-percent level | .7 |

The size of opening left at each end of sleeve-wrapped trays influenced weight loss. The size of this opening depended on the original width of film and the extent of film shrinkage during passage through the heat tunnel. For example, machine oriented polyvinyl

TABLE 1.—*Effect of number of ¼-inch ventilation holes in 3- to 5-pound polyethylene bags of sweetpotatoes on package humidity, oxygen and carbon dioxide concentration, and weight loss*[1]

| Number of holes per bag | Relative humidity in bags held in— 70° F. storage 30-40% R. H. | 70° F. storage 80-85% R. H. | 50° F. storage 85-90% R. H. | Atmosphere[2] Carbon dioxide | Oxygen | Weight Loss[3] |
|---|---|---|---|---|---|---|
| | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| None | 99.8 | 99.3 | 100.0 | 5.2 | 12.5 | 0.1 |
| 4 holes | 98.3 | 99.1 | 99.3 | .8 | 19.5 | .4 |
| 16 holes | 92.8 | 94.2 | — | .5 | 20.7 | 2.1 |
| 24 holes | 88.3 | 91.7 | 96.1 | .4 | 21.0 | 3.6 |
| 48 holes | 85.5 | 89.2 | — | .2 | 20.8 | 4.5 |

[1] Humidity values are the means of 12 to 40 determinations on different days as measured with an electric hygrometer.

[2] Carbon dioxide and oxygen values are the means of 2 tests of 3 bags per treatment determined with an Orsat-type analyzer after 1 and 2 weeks at 70° F.

[3] Weight loss is for cured Porto Rico sweetpotatoes in 5-lb. polyethylene bags held 1 week at 70° F. and 30 to 40 percent relative humidity.

chloride film 11 inches wide left an opening, measuring about 1/4 inch by 2 inches, at each end of the sleeve after shrinking. These openings provided approximately the same area as thirty-two 1/4-inch perforations in the polyethylene bags described earlier, and weight losses were similar. Thus, it appears possible to modify the amount of tray ventilation through choice of film and length of sleeve before shrinking.

The polystyrene and polyvinyl chloride films used for overwrapping were more transparent than the polyethylene bags and provided a clear view of the roots (fig. 1). The polyvinyl chloride films did not tear as easily as the polystyrene films and fewer packages broke during handling.

## Decay and Weight Loss of Packaged Sweetpotatoes

Commercially washed and graded sweetpotatoes held in 3-pound perforated polyethylene bags or bulk baskets after treatment with 1 percent SOPP developed less than 50 percent as much soft rot as nontreated roots (table 2). The chemical treatment had little or no effect on the development of other rots such as end and surface rot (*Fusarium* sp.) and charcoal rot (*Macrophomina phaseoli* (Maub.) Ashby), among others.[2] Packaging sweetpotatoes in polyethylene bags reduced weight losses to approximately one-third that occurring in baskets, but increased sprout growth, especially on the varieties Jersey Orange and Nemagold. However, sprouting was considered of minor importance because of the shortness of the sprouts.

TABLE 2.—*Effect of SOPP treatment and type of container on decay, weight loss, and sprouting of Jersey Orange, Nemagold, and Goldrush sweetpotatoes held 2 weeks at 60°, then displayed 1 week at 70° to 75° F.*

| Variety and container[1] | Chemical treatment | Soft rot | Other rots[2] | Weight loss after— 2 wks. at 60°F | Weight loss after— 2 wks. at 60° plus 1 wk. at 70°-75° | Sprouted[3] |
|---|---|---|---|---|---|---|
| | | *Percent* | *Percent* | *Percent* | *Percent* | *Percent* |
| Jersey Orange[4]: | | | | | | |
| 3-pound polybag | None | 8.3 | 10.0 | 0.9 | 5.2 | 40 |
| 1/2-bushel basket | None | 10.2 | 4.6 | 4.5 | 17.0 | 0 |
| 3-pound polybag | 1% SOPP | 1.5 | 13.6 | .8 | 5.4 | 40 |
| 1/2-bushel basket | 1% SOPP | 4.4 | 5.8 | 4.9 | 15.6 | 0 |
| Nemagold[5]: | | | | | | |
| 3-pound polybag | None | 11.7 | 5.3 | .9 | 5.3 | 67 |
| 1/2-bushel basket | None | 3.9 | 7.1 | 4.1 | 15.3 | 5 |
| 3-pound polybag | 1% SOPP | 5.0 | 7.5 | 1.0 | 5.4 | 57 |
| 1/2-bushel basket | 1% SOPP | 1.2 | 5.8 | 4.5 | 14.5 | 4 |
| Goldrush[6]: | | | | | | |
| 3-pound polybag | None | 4.1 | 2.4 | .3 | 3.3 | 2 |
| 1/2-bushel basket[7] | None | 6.7 | 2.1 | 1.0 | 7.7 | 0 |
| 3-pound polybag | 1% SOPP | 1.2 | 3.1 | .4 | 3.0 | 3 |
| 1/2-bushel basket[7] | 1% SOPP | 2.2 | 2.2 | 1.1 | 9.1 | 0 |

[1] The 3-pound polyethylene bags had thirty-two 1/4-inch perforations and were held in kraft bags during the 2 weeks at 60° F.
[2] Some roots showed small decay spots when tests were initiated.
[3] Sprouts 1/8 to 1/4 inch long.
[4] Average of 2 tests, values are based on 4 to 6 baskets or 16 bags per test.
[5] Average of 4 tests, values are based on 4 to 6 baskets or 16 bags per test.
[6] Average of 3 tests, values are based on 2 baskets or 16 bags per test.
[7] Lined with 2 strips of paper.

Soft rot development was quicker and more extensive than the other forms of decay. Roots were often completely decayed by the soft rot organism within a week, while other forms of decay were usually still confined to one end of the root after a 3-week holding period (table 2). These data indicate that the marketing period for sweetpotatoes should be kept short to avoid excessive shrinkage from moisture loss and decay during bulk display or excessive sprouting in polyethylene bags (fig. 4).

In another test, roots that had been commercially

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[2] The authors are indebted to W. L. Smith, Jr., Market Quality Research Division, Agricultural Marketing Service, Beltsville, Md., and L. W. Nielsen, Department of Plant Pathology, N. C. Agricultural Experiment Station, Raleigh, N. C., for identification of the spoilage organism in several of these tests with sweetpotatoes.

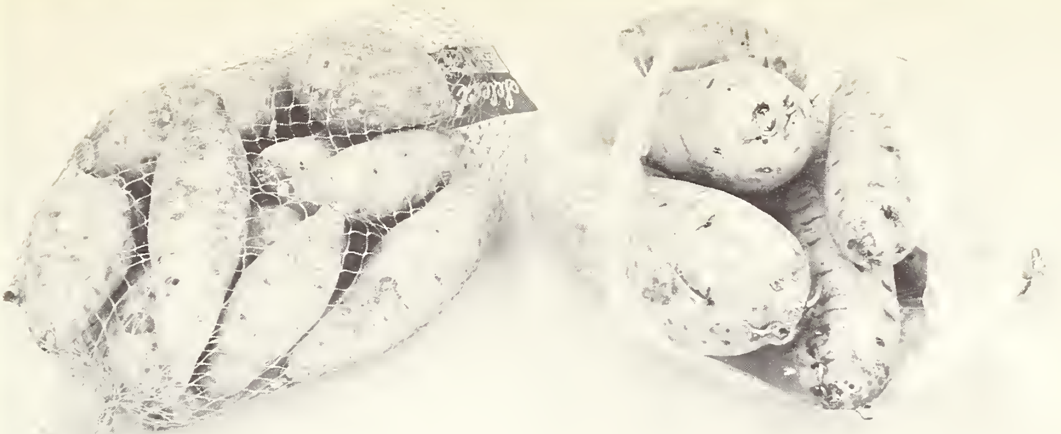

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FIGURE 4.—Desiccation of injuries and shriveling of root ends of sweetpotatoes after several days of simulated store display in polymesh bag (left). Sprout growth on roots after several days of simulated store display in polyethylene bags containing twenty-eight ¼-inch perforations (right, bag cut open).

cured and stored for several months were commercially washed, graded, sized, treated with 1 percent SOPP by dipping, and held in three types of containers under simulated store conditions (table 3). There were no significant differences in the development of decay in the various containers, but more decay developed than was expected. Examination of the roots and a check with the packinghouse management disclosed that part of the decay developed as a result of chilling injury before the test.

Freshly harvested (noncured) roots that were handled commercially during washing, grading, sizing, and treatment with 0.5 percent SOPP were obtained another season and also held under simulated market-

TABLE 3.—*Weight loss, shriveling, and decay of cured sweetpotatoes commercially graded, treated with 1 percent SOPP and packaged in different containers, April 1962*[1]

| Type of examination and holding period | Bushel basket [2] | 3-pound polymesh bag [3] | 3-pound polyethylene bag [3] |
|---|---|---|---|
| | *Percent* | *Percent* | *Percent* |
| Weight loss: | | | |
| During 3-4 days at 60° F. | 0.3 | 1.6 | 0.3 |
| During 6-7 days at 70° F. | 7.2 | 7.5 | 2.7 |
| Total (cumulative) | 7.5 | 9.1 | 3.0 |
| Condition of roots after 3-4 days at 60° F. plus 6-7 days at 70°-80°: | | | |
| Shriveled | 8.8 | 10.3 | .3 |
| Decayed | 5.1 | 5.8 | 3.1 |
| Bags underweight:[4] | | | |
| After filling | — | 3 | 8 |
| After 3-4 days at 60° F. | — | 10 | 8 |
| After 3-4 days at 60° F. plus 6-7 days at 70°-80° F. | — | 88 | 32 |
| Bags unsalable due to decay: | | | |
| After 3-4 days at 60° F. plus 6-7 days at 70°-80° F. | — | 33 | 21 |

[1] Average of 4 tests with Goldrush and Centennial roots held 3 to 4 days at 60° F. (80 to 85 percent relative humidity) and then displayed 6 to 7 days at 70° to 80° (35 to 60 percent relative humidity). During the holding period, bagged sweetpotatoes were in corrugated master containers. On display, the bagged sweetpotatoes were stacked alongside those on bulk display from the baskets.

[2] Bushel baskets had a paper liner.

[3] Average initial gross weight of the bagged sweetpotatoes was 3.2 pounds. Polyethylene bags contained twenty-eight ¼-inch holes.

[4] Net weight of less than 3 pounds.

TABLE 4.—*Weight loss, shriveling, and decay of freshly harvested noncured sweetpotatoes commercially graded, treated with 0.5 percent SOPP and packaged in different containers, September 1962*[1]

| Type of examination and holding period | Bushel basket [2] | 3-pound polymesh bag [3] | 3-pound polyethylene bag [3] | 3-pound tray with sleeve wrap [3] |
|---|---|---|---|---|
| | *Percent* | *Percent* | *Percent* | *Percent* |
| Weight loss: | | | | |
| During 3-4 days at 60° F. | .8 | 1.3 | .3 | .7 |
| During 6-7 days at 70°-80° F. | 8.3 | 9.2 | 1.2 | 4.4 |
| Total (cumulative) | 9.1 | 10.5 | 1.5 | 5.1 |
| Condition of roots after 3-4 days at 60° F. plus 6-7 days at 70°-80° F.: | | | | |
| Shriveled | 25.4 | 19.6 | 1.6 | 1.8 |
| Decayed | 1.2 | 1.1 | 1.8 | .8 |
| Packages underweight: [4] | | | | |
| After filling | — | 0 | 4 | 0 |
| After 3-4 days at 60° F. | — | 2 | 4 | 0 |
| After 3-4 days at 60° F. plus 6-7 days at 70°-80° F. | — | 63 | 6 | 0 |
| Packages unsalable due to decay: | | | | |
| After 3-4 days at 60° F. plus 6-7 days at 70°-80° F. | — | 6 | 12 | 4 |

[1] Average of 4 tests with Centennial and Nugget roots held 3 to 4 days at 60° F. (80-85 percent relative humidity) and then displayed 6 to 7 days at 70° to 80° (35 to 60 percent relative humidity). During the holding period the 3-pound packages were held in corrugated master containers. On display the 3-pound packages were stacked alongside bulk displays from the baskets.

[2] Bushel baskets had a paper liner.

[3] Average initial gross weight of the bagged and tray-packed sweetpotatoes was 3.3 pounds. Polyethylene bags contained twenty-eight ¼-inch holes. The pulp tray (8½ x 9 inches) was overwrapped with 100-gage polystyrene biaxially oriented shrink film originally 11 inches in width.

[4] Gross weight of less than 3 pounds.

ing conditions in various containers (table 4). Less than 2 percent of the roots decayed during a 10-day period. Although no direct comparison was made between cured and noncured sweetpotatoes, a comparison of the data in tables 3 and 4 indicates that there was very little difference in weight losses whether the roots were freshly harvested, and had lost an estimated 2 to 5 percent of their skin, or had been cured and stored and had lost less than 1 percent of their skin during grading.

In both tests, there were large differences in weight losses of sweetpotatoes in various containers. The roots originally in bushel baskets and displayed in bulk lost enough weight to have a poor appearance 10 days after grading. The roots in polymesh consumer bags responded similarly, and in addition more than 60 percent were below the 3-pound specified weight after the 10-day test. The least weight was lost by sweetpotatoes in the perforated polyethylene bags, as noted by other workers (*4, 45*). Less than a third of the polyethylene bags were below the 3-pound weight after 10 days. The loss of weight from 3-pound tray packs was intermediate between polymesh and polyethylene bags. However, because of uniformity in original weight and an adequate overweight, none were below 3-pounds after the 10-day holding period. Further results of these tests, published elsewhere (*14*), show losses actually experienced with comparable roots sold in retail stores. In general, losses were less in stores than reported here, indicating that in actual practice losses should not exceed those given in tables 3 and 4.

The amount of overweight to allow for shrinkage is also influenced by the size of the roots packaged. It is much easier to package close to a tolerance with small roots than with large roots. Use of small roots permits packaging with a smaller average overweight allowance, but the slightly greater weight loss by small roots (table 5) may nullify this advantage. The difference in weight loss due to size of roots was unimportant when losses were low (as in polyethylene bags), but important when losses were high (as in polymesh bags).

## Method of Rinsing After Treatment

Roots treated with SOPP should be rinsed with water soon afterwards to reduce the danger of chemical injury, evidenced as a discoloration of skinned areas (*13, 29*). Spray rinsing on a roller conveyor is an accepted commercial method of preventing this type of chemical injury. A test was initiated to determine if sweetpotatoes could be packaged in polyethylene mesh bags and then treated with SOPP and rinsed. Treatment with SOPP after packaging in polyethylene

TABLE 5.—*Weight loss from different size sweetpotatoes during holding in different types of 3-pound consumer packages packed in April and September 1962* [1]

| Type of package and size of sweetpotatoes | Weight loss after indicated period — | | | |
|---|---|---|---|---|
| | 3-4 days at 60°F. | | 3-4 days at 60°F. plus 6-7 days at 70° - 80°F. | |
| | April Packed (Cured) | Sept. Packed (Noncured) | April Packed (Cured) | Sept. Packed (Noncured) |
| | *Percent* | *Percent* | *Percent* | *Percent* |
| Polyethylene bags: | | | | |
| Large roots (2¼-3¼" dia.) | 0.3 | 0.2 | 2.5 | 1.2 |
| Small roots (1¼-2¼" dia.) | 0.3 | 0.3 | 2.8 | 1.3 |
| Polymesh bags: | | | | |
| Large roots (2¼-3¼" dia.) | 1.7 | 1.2 | 7.2 | 8.5 |
| Small roots (1¼-2¼" dia.) | 2.0 | 1.5 | 8.3 | 10.2 |
| Molded-pulp tray, sleeve wrap: [2] | | | | |
| Large roots (2¼-3¼" dia.) | — | .6 | — | 4.1 |
| Small roots (1¼-2¼" dia.) | — | .6 | — | 4.7 |

[1] Values are means of 3 tests (24 bags) with April-packed roots cured and 4 tests (24 packages) with September-packed roots noncured per treatment. During holding the packages were held in corrugated master containers at 60° F. (80 to 85 percent relative humidity) and then displayed at 70° to 80° (35 to 60 percent relative humidity). Polyethylene bags contained twenty-eight ¼-inch holes.

[2] Sleeve overwrap of 100-gage polystyrene biaxially oriented shrink film originally 11 inches in width on 8½- by 9-inch tray.

mesh bags followed by a brief immersion in water did not reduce the control of decay, as shown in table 6. The paper labels on the bags were stained slightly and wrinkled by this procedure, but the plastic mesh bags were not affected by the treatment.

TABLE 6.—*Development of soft rot in injured Goldrush sweetpotatoes treated with SOPP and rinsed with a water spray or briefly immersed in water and then held 7 days at 60° F.* [1]

| Treatment and concentration | Method of rinsing [2] | Sweetpotatoes with soft rot at— | |
|---|---|---|---|
| | | Bruises | Root breaks |
| | | *Percent* | *Percent* |
| Nontreated | Spray on rollers [3] | 75 | 3 |
| Nontreated | Immersion of bags [3] | 92 | 13 |
| 0.5% SOPP dip | Spray on rollers | 3 | 0 |
| 0.5% SOPP dip | Immersion of bags | 0 | 0 |
| 1.0% SOPP dip | Spray on rollers | 0 | 0 |
| 1.0% SOPP dip | Immersion of bags | 0 | 0 |

[1] Data based on 4 replicates of 10 roots each.

[2] Spray rinsing consisted of passing roots under a single row of nozzles delivering about 1 gallon of water per minute on a roller conveyor moving about 33 feet per minute. This was done before packaging. Bags used in packaging were polyethylene mesh.

[3] Rinsed only.

## Root Trimming and Holding Temperature

A preliminary test indicated that trimming sweetpotato root ends to fit tray packs did not increase decay if roots were treated with SOPP after trimming (*29*). Badger (*4*), in a sweetpotato marketing study, reported that consumers prefer a tray pack. In three tests conducted with Goldrush sweetpotatoes, it was found that trimming root ends did not increase decay or weight loss (table 7).

Holding temperature influenced the kind of decay more than it did the total amount of decay during the 2-week holding period. As expected, weight loss was greater at 70° F. than at 60° because the lower relative humidity at 70°, together with the higher temperature, produced a greater vapor pressure deficit and consequently more evaporation from the sweetpotatoes.

## Delaying Chemical Treatment

For various reasons sweetpotatoes may be injured before they are chemically treated and packaged. The time interval between injury and treatment may be several days; that is, roots may be moved from storage to the packinghouse but not graded, or roots may be washed and graded and the No. 2 or commercial grades may be removed before the roots are chemically treated. In either case, injuries are inflicted and packinghouse operators have asked how long after injury the preservative chemical treatment can be given with reasonable success.

TABLE 7.—*Effect of holding temperature, root trimming, and treatment with SOPP upon weight loss and decay of Goldrush sweetpotatoes packaged in perforated polyethylene bags* [1]

| Storage conditions and treatment | Weight loss | Decay [2] |
|---|---|---|
| | *Percent* | *Percent* |
| 2 weeks 60° F. with 80-90% RH: | | |
| Washed, nontreated | 0.6 | 1.3 |
| Washed, treated with 0.5% SOPP | .5 | .3 |
| Washed, nontreated, ends trimmed | .5 | .6 |
| Washed, treated with 0.5% SOPP, ends trimmed | .6 | .3 |
| 2 weeks 70° F. with 70-85% RH: | | |
| Washed, nontreated | 1.8 | 1.7 |
| Washed, treated with 0.5% SOPP | 2.8 | 1.3 |
| Washed, nontreated, ends trimmed | 2.5 | 1.0 |
| Washed, treated with 0.5% SOPP, ends trimmed | 2.8 | 1.0 |

[1] Average of 3 tests of 4 bags per treatment per test with 25 small roots (1 inch to 2 inches in diameter) per bag. All polyethylene bags were perforated with thirty-two ¼-inch holes. Bags measured 8 by 3 by 19 inches. Trimming consisted of removing both ends from all roots.

[2] Mostly soft rot *(Rhizopus sp.)* at 60° but mostly end rot (*Fusarium* sp.) at 70° F. Differences not statistically significant.

It was found that roots could be injured, held up to 4 days at 50° F., and then chemically treated, and the treatment still would reduce subsequent development of soft rot enough to warrant the expense (table 8). At 60°, decay control with the SOPP treatment decreased with each day of delay and was much less effective by the third day than immediate treatment. At 70°, soft rot control decreased nearly 50 percent when roots were treated on the third day, compared with immediate treatment. Holding roots at 85° is an effective means of controlling soft rot, and SOPP treatment is unnecessary (*39*).

Roots may be inoculated with black rot during washing and grading or in the field at harvest (*16, 20, 28, 30, 40*). Therefore, a similar study on the effect of delayed chemical treatment was made on sweetpotato pieces inoculated with black rot (table 8). At 50° F. black rot grows very little, so this temperature was not used. Control of black rot with SOPP decreased with each day of delay before treating at holding temperatures at 70° and 85°, but was reasonably good when roots were treated after 2 days at 70°, or 1 day at 85°. At 60° delayed chemical treatments were still effective against black rot after 4 days.

Chemical injury was usually noted when the treated root pieces were placed at 85° F. The root pieces used in the black rot test were not rinsed after treatment, as recommended. Supplementary data indicate that SOPP causes more injury on roots held at 85° than on roots held at lower temperatures.

TABLE 8.—*Effect of delayed treatment with 1.0 percent SOPP on development of soft rot of bruised Goldrush sweetpotato roots or on development of black rot on inoculated root pieces*

| Treatment and storage period | Sweetpotatoes decayed with— Soft rot after 14 days [1] | Sweetpotatoes decayed with— Black rot after 12 days [2] |
|---|---|---|
| | *Percent* | *Percent of surface* |
| Nontreated control held at— | | |
| 60° | 73 | 100 |
| 70° | 23 | 100 |
| 85° | — | 100 |
| Treated immediately, held at 60° | 3 | [3] 7 |
| Treated after— | | |
| 2 days at 50° | 8 | — |
| 4 days at 50° | 3 | — |
| 7 days at 50° | 35 | — |
| 1 day at 60° | 8 | [3] 3 |
| 2 days at 60° | 20 | [3] 1 |
| 3 days at 60° | 38 | 2 |
| 4 days at 60° [4] [5] | 50 | 5 |
| 1 day at 70° | 3 | [3] 2 |
| 2 days at 70° | 8 | [3] 3 |
| 3 days at 70° [5] | 10 | 15 |
| 4 days at 70° [4] [5] | 28 | 20 |
| 1 day at 85° | — | [3] 0 |
| 2 days at 85° | — | [3] 10 |
| 3 days at 85° [5] | — | [3] 18 |
| 4 days at 85° [5] | — | [3] 100 |

[1] Roots had been cured and stored before being washed, injured, treated 30 seconds with SOPP and rinsed, packaged in kraft bags, and held at 60° F. to allow soft rot to develop.

[2] For black rot, root pieces were inoculated and held in moist chambers until treated, but not rinsed; then held at 80° to 85° F. in moist chambers until examined.

[3] Some chemical injury because sweetpotatoes were not rinsed following treatment for black rot control.

[4] Some soft rot visible when treated.

[5] Some black rot mycelium visible when treated.

## Chilling Before Chemical Treatment

Chilling injury weakens or predisposes sweetpotatoes to decay caused by the soft rot organism (*39*). The question arose whether SOPP treatment would reduce or eliminate soft rot in chilled sweetpotatoes. If so, it would increase the danger of marketing roots of poor table quality (*12*).

Roots chilled up to 16 weeks at 50° F. developed no more soft rot in this experiment than nonchilled roots when the ends of each root were broken off after chilling (table 9). However, very little decay developed in either untreated or treated roots when unchilled or chilled up to 16 weeks at 50°. Roots chilled for 4 weeks or more at 40° developed considerable soft rot after the root ends were broken off. Treatment with SOPP reduced decay less than one-third. It is concluded that soft rot induced by chilling is reduced slightly but not satisfactorily controlled with SOPP treatment. Roots chilled 8 and 16 weeks at 50° or 2 weeks at 40° were not consistently of poor table quality when baked. Those that did not keep well after chilling (4 weeks or more at 40° ) did not taste good. Thus, the poor keeping quality of chilled sweetpotatoes was associated with poor table quality.

TABLE 9.—*Effect of previous chilling of Goldrush sweetpotatoes on the effectiveness of SOPP in reducing soft rot of injured (broken ends) roots* [1]

| Chilling treatment | Sweetpotatoes with soft rot after 10 days at 60°F. Not treated | Sweetpotatoes with soft rot after 10 days at 60°F. Treated [2] |
|---|---|---|
| | *Percent* | *Percent* |
| None (60°F. continuously) | 4 | 0 |
| 50°F. storage: | | |
| 4 weeks | 1 | 0 |
| 8 weeks | 0 | 1 |
| 12 weeks [3] | 2 | 0 |
| 16 weeks [3] | 4 | 0 |
| 40°F. storage: | | |
| 2 weeks | 2 | 1 |
| 4 weeks | 18 | 8 |
| 6 weeks | 15 | 14 |
| 8 weeks | 32 | 22 |

[1] Except as noted, data represent the averages of 2 tests with 80 roots per treatment in each test. Both ends of each root broken off after chilling. All roots washed and packaged in ½-bushel baskets and cured before the treatments were initiated.

[2] Immersed in 1.0 percent SOPP for 30 seconds, drained, and packaged; not rinsed after treatment.

[3] Based on one test only.

# Literature Cited

(1) ANONYMOUS.
1946. FUTURE OF THE YAM IS IN THE BAG. Sweet Potato Jour. 1(4): 3, 13.

(2) ANONYMOUS.
1961. A "SWEET" PACKAGE. Amer. Veg. Grower 9(8): 18-19.

(3) ABRAHAMSEN, M. A.
1947. CONSUMER PREFERENCES FOR SWEET POTATOES. N. C. Agr. Expt. Sta. Tech. Bul. 82.

(4) BADGER, D. D.
1961. CONSUMER ACCEPTANCE FOR PREPACKAGED AND BULK SWEET POTATOES. Va. Agr. Expt. Sta., Dept. Agr. Econ., Res. Rpt. 56.

(5) ———— and MATTUS, G. E.
1961. FUNGICIDE RESEARCH FOR PREVENTING DECAY OF NEMAGOLD SWEET POTATOES. Va. Agr. Expt. Sta., Dept. Agr. Econ., Res. Rpt. 55.

(6) BAKER, J. M.
1947. CONSUMER PREFERENCES IN SWEET POTATOES. La. Agr. Expt. Sta. Bul. 409.

(7) ————
1947. MARKETING LOUISIANA SWEET POTATOES IN PITTSBURGH. La. Agr. Expt. Sta. Bul. 422.

(8) ————
1954. EFFECT OF SIZING SWEET POTATOES ON CONSUMER ACCEPTANCE. La. Agr. Expt. Sta. Dept. Agr. Econ. Cir. 166.

(9) BEAL, G. M., and VOELKEL, R. F.
1958. MARKETING OF MARYLAND SWEET POTATOES. Md. Agr. Expt. Sta. Misc. Pub. 320.

(10) COLLINS, N. R., GREIG, J. K., and TUCKER, H.
1956. CONSUMER PREFERENCES FOR SWEET POTATOES. Kans. Agr. Expt. Sta. Agr. Econ. Rpt. 70.

(11) Cooley, J. S., and Kushman, L. J.
1951. EFFECT OF PASTEURIZATION ON BLACK ROT OF SWEET POTATOES. Phytopath. 41 (9): 801-803.

(12) ————, Kushman, L. J., and Smart, H. F.
1954. EFFECT OF TEMPERATURE AND DURATION OF STORAGE ON QUALITY OF STORED SWEET POTATOES. Econ. Bot. 8(1): 21-28.

(13) Covington, H. M.
1960. TREATING SWEET POTATOES WITH SOPP. N. C. Agr. Expt. Sta. Hort. Inform. Leaf. 93.

(14) ————
1962. PRELIMINARY STUDIES OF PACKAGING SWEET POTATOES, APRIL AND SEPTEMBER, 1962. N. C. Agr. Expt. Sta. Ext. Serv. Mimeo. Rpt.

(15) Cox, J. A., and Martin, W. J.
1952. LOUISIANA YAMS FOR TABLE AND TRADE. La. State Univ. and Agr. and Mech. Coll. Agr. Ext. Pub. 1121.

(16) ————, Martin, W. J., and Kantack, E. J.
1958. LOUISIANA SWEET POTATOES. La. State Univ. and Agr. and Mech. Coll. Agr. Ext. Pub. 1121 (rev.).

(17) Daines, R. H.
1941. PRE-MARKET SWEET POTATO DIPS: EFFECT ON SOFT ROT SHRINKAGE AND APPEARANCE. N. J. Agr. Expt. Sta. Plant Disease Notes. 18 (21): 45-48.

(18) ————
1942. SOFT ROT OF SWEET POTATOES AND ITS CONTROL. N. J. Agr. Expt. Sta. Bul. 698.

(19) Ecton, P. T.
1948. CONSUMER PACKAGING PRESENTS MANY PROBLEMS TO LOUISIANA YAM GROWER. Pre-Pack-Age 1 (5): 9.

(20) Elmer, O. H.
1960. SWEET POTATOES AND THEIR DISEASES. Kans. Agr. Expt. Sta. Bul. 426.

(21) Feazell, J. A., and Martin, W. J.
1952. EVALUATION OF ERADICANT FUNGICIDES AGAINST *Ceratostomella fimbriata*. Phytopath. 42: 7 (Abstract).

(22) Ferrier, W. T.
1944. MARKETING SOUTH CAROLINA SWEET POTATOES. S. C. Agr. Expt. Sta. Bul. 352.

(23) Ford, K. E.
1949. THE EFFECT OF SHIPPING POINT TREATMENTS ON CONSUMERS' PREFERENCES FOR SWEET POTATOES. GA. AGR. Expt. Sta. Mimeo. Ser. 8.

(24) Ford, K. E.
1950. WASTE AND SPOILAGE LOSSES IN MERCHANDISING SWEET POTATOES AT THE RETAIL STORE. Ga. Agr. Expt. Sta. Mimeo. Ser. 24.

(25) Ginn, John L.
1962. EVALUATION OF SELECTED CONSUMER PACKAGES AND SHIPPING CONTAINERS FOR PEACHES. U. S. Dept. Agr. Mktg. Res. Rpt. 533, 27 pp., illus.

(26) Hardenburg, R. E.
1954. HOW TO VENTILATE PACKAGED PRODUCE. Pre-Pack-Age 7 (6): 14-17.

(27) Jeffers, W. F.
1947. EVALUATION OF SEVERAL FUNGICIDES IN PREVENTING INFECTION OF SWEETPOTATO SLICES BY *Ceratostomella fimbriata*. (Abst.). Phytopath. 37: 439.

(28) Kushman, L. J.
1959. CURING OF PORTO RICO SWEETPOTATOES AT 95° F FOR PREVENTION OF BLACK ROT IN STORAGE. Amer. Soc. Hort. Sci. Proc. 73: 467-472.

(29) ————
1961. FUNGICIDAL CONTROL OF DECAY IN PORTO RICO SWEETPOTATOES DURING MARKETING, A PROGRESS REPORT. U. S. Dept. Agr. AMS–452, 19 pp.

(30) ———— and Cooley, J. S.
1949. EFFECT OF HEAT ON BLACK ROT AND KEEPING QUALITY OF SWEETPOTATOES. Jour. Agr. Res. 78: 183-190.

(31) Kushman, L. J., and Deonier, M. T.
1959. RELATION OF INTERNAL GAS CONTENT AND RESPIRATION TO KEEPING QUALITY OF PORTO RICO SWEETPOTATOES. Amer. Soc. Hort. Sci. Proc. 74: 622-641.

(32) ———— and Ramsey, G. B.
1958. A PRELIMINARY REPORT ON THE CONTROL OF DECAY OF PORTO RICO SWEETPOTATOES DURING MARKETING. Plant Dis. Rptr. 42: 247-249.

(33) ————, Ramsey, G. B., Smith, M. A., and Wright, W. R.
1951. TEMPERATURE AND QUALITY RECORDS FOR SWEETPOTATO TRUCK SHIPMENTS, 1950-51 SEASON. U. S. Dept. Agr. Bur. Plant Indus., Soils and Agr. Engin., H. T. & S. Off. Rpt. 254.

(34) Law, J. M.
1955. CONSUMER REACTION TO SIZED SWEET POTATOES. La. Rural Econ. 17: 2-3.

(35) ———— and Hanes, J. K.
1958. EXPERIMENTS WITH SIZING SWEET POTATOES BY MACHINE. La. Rural Econ. 20: 3-5.

(36) ————, and Hanes, J. K.
1958. CONSUMER REACTION TO PREPACKAGED LOUISIANA SWEET POTATOES. La. Agr. Expt. Sta. Dept. Agr. Econ. Cir. 220.

(37) Lutz, J. M., Ramsey, G. B., and Cooley, J. S.
1946. RECORDING OF TEMPERATURES SHOWS NEED FOR IMPROVEMENTS. Sweet Potato Jour. 1 (4): 4-5.

(38) Lutz, J. M., and Simons, J. W.
1958. STORAGE OF SWEETPOTATOES. U. S. Dept. of Agr. Farmers Bul. 1442, 42 pp., illus.

(39) McClure, T. T.
1959. RHIZOPUS DECAY OF SWEET POTATOES AS AFFECTED BY CHILLING, RECURING, AND HYDROWARMING AFTER STORAGE. Phytopath. 49: 359-361.

(40) Martin, W. J., Lutz, J. M., and Ramsey, G. B.
1949. CONTROL OF BLACK ROT IN WASHED, UNCURED SWEETPOTATOES. Phytopath. 39: 580-582.

(41) Person, L. H.
1942. DIPPING SWEET POTATOES TO CHECK BLACK ROT. La. Agr. Expt. Sta. Ann. Rpt.

42) Phillips, C. D.
1951. BUYING PRACTICES OF LOUISVILLE CONSUMERS FOR SWEET POTATOES, SWEET CORN, AND POTATOES. Ky. Agr. Expt. Sta. Bul. 574.

(43) Ramsey, Glen B., Friedman, B. A., and Smith, M. A.
1959. MARKET DISEASES OF BEETS, CHICORY, ENDIVE, ESCAROLE, GLOBE ARTICHOKES, LETTUCE, RHUBARB, SPINACH, AND SWEETPOTATOES. U. S. Dept. Agr. Handb. 155, illus.

(44) Schomer, H. A.
1953. FILMS FOR PRODUCE. Mod. Packaging 26(8): 191-196.

(45) Scott, L. E.
1962. HANDLING TESTS WITH FRESHLY HARVESTED AND STORED SWEET POTATOES. (Abstract) Assoc. South. Agr. Workers Proc. 59: 182-183.

(46) Senn, T. L., and Scott, L. E.
1959. STORAGE BEHAVIOR OF THE SWEET POTATO (*Ipomoea batatas* LAM.) AS INFLUENCED BY MODIFIED ATMOSPHERES. (Abstract) Assoc. South. Agr. Workers Proc. 56: 169.

(47) Seufferle, C. H., Burdette, R. F., Hamilton, A. B., and Devault, S. H.
1940. PRODUCTION AND MARKETING OF MARYLAND SWEET POTATOES. Md. Agr. Expt. Sta. Bul. 436.

(48) Thomas, W. H.
1962. CONSUMER ACCEPTANCE OF PACKAGED SOUTH CAROLINA PEACHES IN SELECTED SUPERMARKETS. S. C. Agr. Expt. Sta. Cir. 132.

(49) U. S. Department of Agriculture.
1954. LOSSES IN AGRICULTURE, A PRELIMINARY APPRAISAL FOR REVIEW. ARS-20-1.

(50) Von Tungeln, George R.
1963. GLAMOUR PACKAGE SELLS MORE SWEET POTATOES. Prod. Mktg. 6(7): 15, 16.

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